California Integrated Waste Management Board

Life Cycle Assessment and Economic Analysis of Organic Waste Management and GHG Reduction Options

July 22, 2009

R·W·BECK

Mind Powered: Insight with Impact.

Presentation Summary

- Introduction
  - Economic Study Objectives
  - Economic Study Boundaries
  - Economic Data
- Economic Model
  - Methodology
  - Key Assumptions
  - Total Waste System Net Costs
- Results
- Next Steps

Economic Study Objectives

- Economic Analysis
  - Determine $/ton and $/MTCO2e for 7 organics and recycling options
  - Five study years (2006, 2010, 2015, 2020, 2025)
  - 3 California regions and the state
- Input/Output Model Analysis
  - Determine direct and indirect impacts of 7 organics and recycling options
  - Study year – 2006
  - 3 California regions and the state

Economic Study Boundaries – Economic Analysis

- Economic model assumptions needed to be consistent with LCA
  - Revenues and costs captured collection, processing, transportation to end use and final disposal.
  - Financial pro formas created for on a <u>per material</u> basis for:
    - 14 different materials
    - 5 study time periods
    - 3 regions and the state (total of 4)
    - 7 solid waste management options

Economic Study Boundaries – Economic Analysis

- Economic analysis did not include a detailed analysis of waste option technology cost differentials, i.e. average values or industry surrogates were used.
- GHG tool will include some flexibility to modify values to better reflect changes in key assumptions such as costs and revenues.

Economic Study Boundaries – Input/Output Model Analysis

- Used IMPLAN model.
- Input/Output Model Analysis focused on the 7 options and did not include collection and transportation components.
- Analysis conducted on a state and regional basis.
- Worked predominantly with data used in the financial analysis.

Economic Data

- Most significant challenge of this project was obtaining high quality data on which to base projections.
- Data used included a mix of:
  - Data received from CA-based operating facilities
  - Data from CA-based studies commissioned by CA-based utilities
  - Interviews with CA-based business involved in various aspects of solid waste management
  - Data developed by R.W. Beck
  - Data from published sources such as industry reports and articles
  - Vendor-provided data

Economic Model

Projected Tonnage by Material Composition, Region and Year *(RTI)*

Net Greenhouse Gas Emissions *(RTI)*

General Assumptions and Parameters

(Default values can be modified)

Unit Net Costs Assumptions for each Waste Management Option ($/Ton)

(Default values can be modified)

Total System Net Costs:
- Collection Costs
- Waste Management Option Net Costs
- Transportation Costs

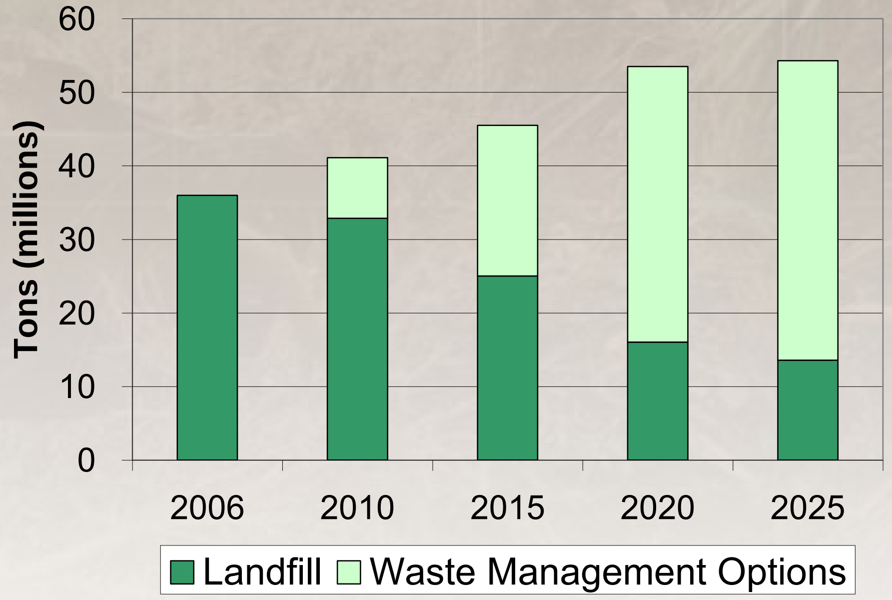
Results:
- Total Costs by Material and Waste Management Option for each Study Year
- Total Unit Costs
  - $/ton
  - $/MTCO2e
- Number of Additional Facilities for each Waste Management Option

Key Assumptions – Tonnage Projection Methodology

- Baseline 2006 tonnage disposed.
- Overall composition data from the Board's "Statewide Waste Characterization Study", December 2004.
- Projections based on Board projections through 2025.
- Reviewed landfill diversion policies for each region.
- Assumes waste composition does not change in future years.
- No data available to determine the flow of waste between regions.

Key Assumptions – General

- Landfilled Tonnage:
  - Reviewed landfill diversion policies for each region.
  - Assumes 75% max. diversion of landfilled tonnage by 2025 for the state and regions.



Key Assumptions – Tonnage to Options Methodology Example

	AD (2)				BTE				Chipping/Grinding				Composting				Recycling				WTE			
	2010	2015	2020	2025	2010	2015	2020	2025	2010	2015	2020	2025	2010	2015	2020	2025	2010	2015	2020	2025	2010	2015	2020	2025
California State (1)																								
ORGANICS																								
Leaves and Grass	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y
Prunings and Trimmings	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y
Southern Bay Area (1)																								
ORGANICS																								
Leaves and Grass	Y	Y	Y	Y	**N/A**	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	**N/A**	**N/A**	Y	Y
Prunings and Trimmings	N	N	N	N	**N/A**	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	**N/A**	**N/A**	Y	Y

Notes:

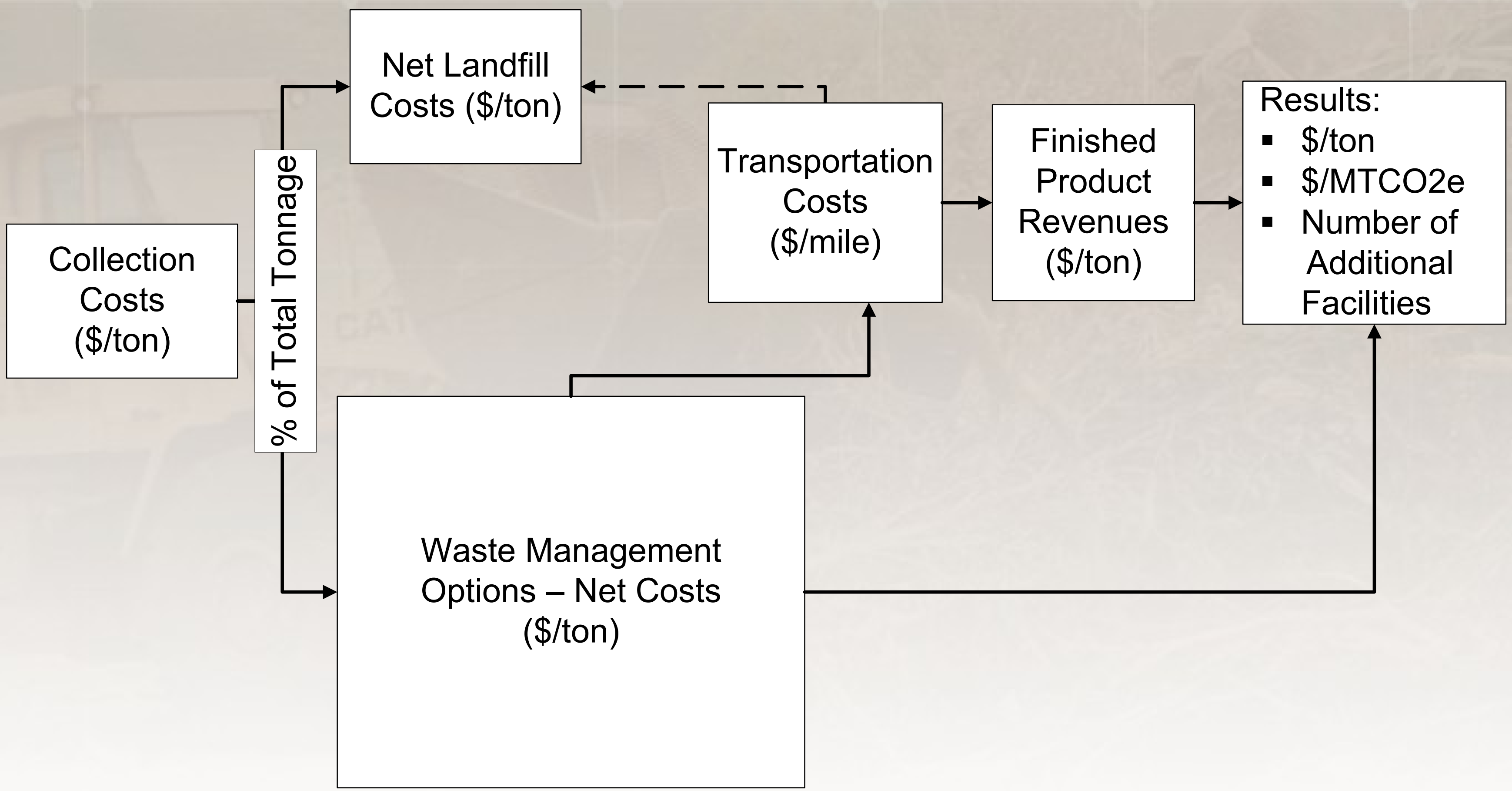
(1) All material categories will have some portion of the tonnage sent to landfills.
"N/A" means this option does not exist or is likely not available for this region during this time period.

(2) AD includes the use of excess digester capacity at existing WWTP, dairy farms and stand alone units.

Total Waste System Net Costs

- Collection Costs
- Waste Management Option Net Costs
  - Revenues
  - Operating and Maintenance Costs
  - Annual Capital Costs
  - Additional Facility Costs
- Transportation Costs
  - Product to Foreign Markets
  - Product to Domestic Markets
  - Residuals

Total Waste System Net Costs



Key Assumptions – Collection

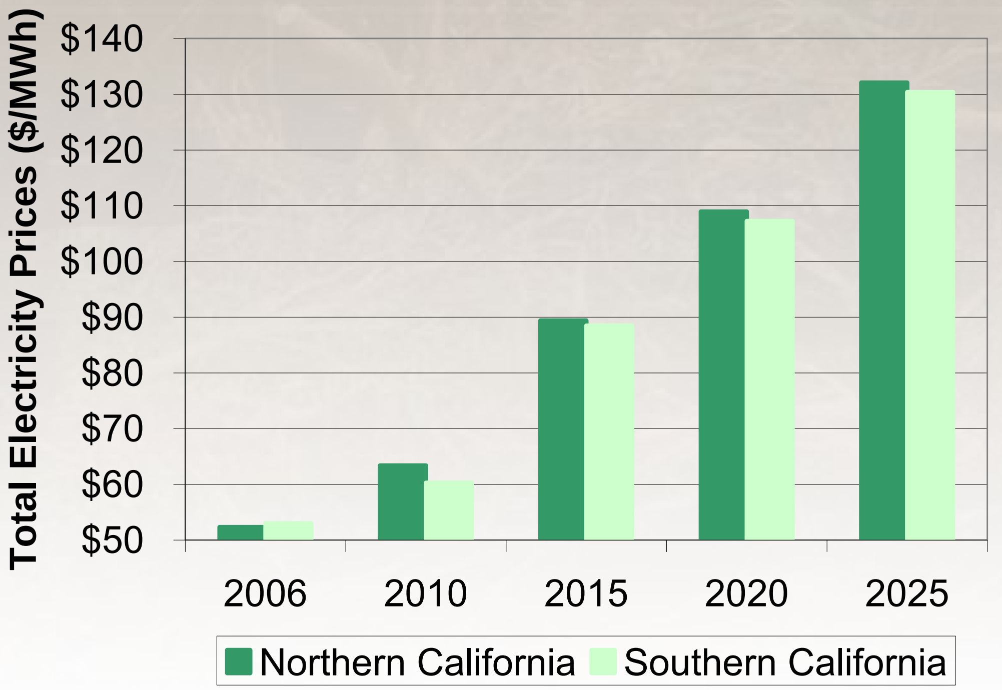
- Collection Split (Based on 2004 CIWMB Waste Characterization Study)
  - 40% Residential
  - 60% Commercial
- Assumed $150/ton for residential collection
- Assumed $120/ton for commercial collection
- Factors developed from secondary research and project team experience.

Total Waste System Net Costs – Revenues

- Based on data collected and modeled on a $/ton basis.
- Revenue Projections:
  - Operating Revenues (Tipping Fees): General inflation
  - Electricity and Biogas Revenues: Market price of energy/capacity and natural gas projections developed by R. W. Beck
  - Recyclables Revenues: 7% annual increase
  - Sale of Soil Amendment, Compost and Other Revenues: General inflation
  - Carbon Credits Revenues: Included for anaerobic digestion, BTE and composting

Key Assumptions – Revenue Projections for Options

- Energy Revenues:
  - Based on change in market price projections for Northern and Southern California



Total Waste System Net Costs – Revenues

- Revenue projections were only developed for the waste management options.
- No revenues were projected to recover the collection and transportation component of costs.
- Regional differences were reflected using the California Wage Price Index if data was not available.
- Changes in technology and operations are reflected in projected revenues.

Total Waste System Net Costs – Operating and Maintenance Costs

- Based on data collected and modeled on a $/ton basis.
- Operating cost projections based on general inflation.
- Assumed to be mostly labor and O&M expenses; no depreciation and debt service.
- Changes in technology or operations are reflected in projected operating costs if data was available.
- Regional differences were reflected using the California Wage Price Index if data was not available.
- Costs were compared to the project team's experience on similar projects and vendor estimates to gauge the degree of reasonableness.

Key Assumptions – Future Technology Changes

Composting

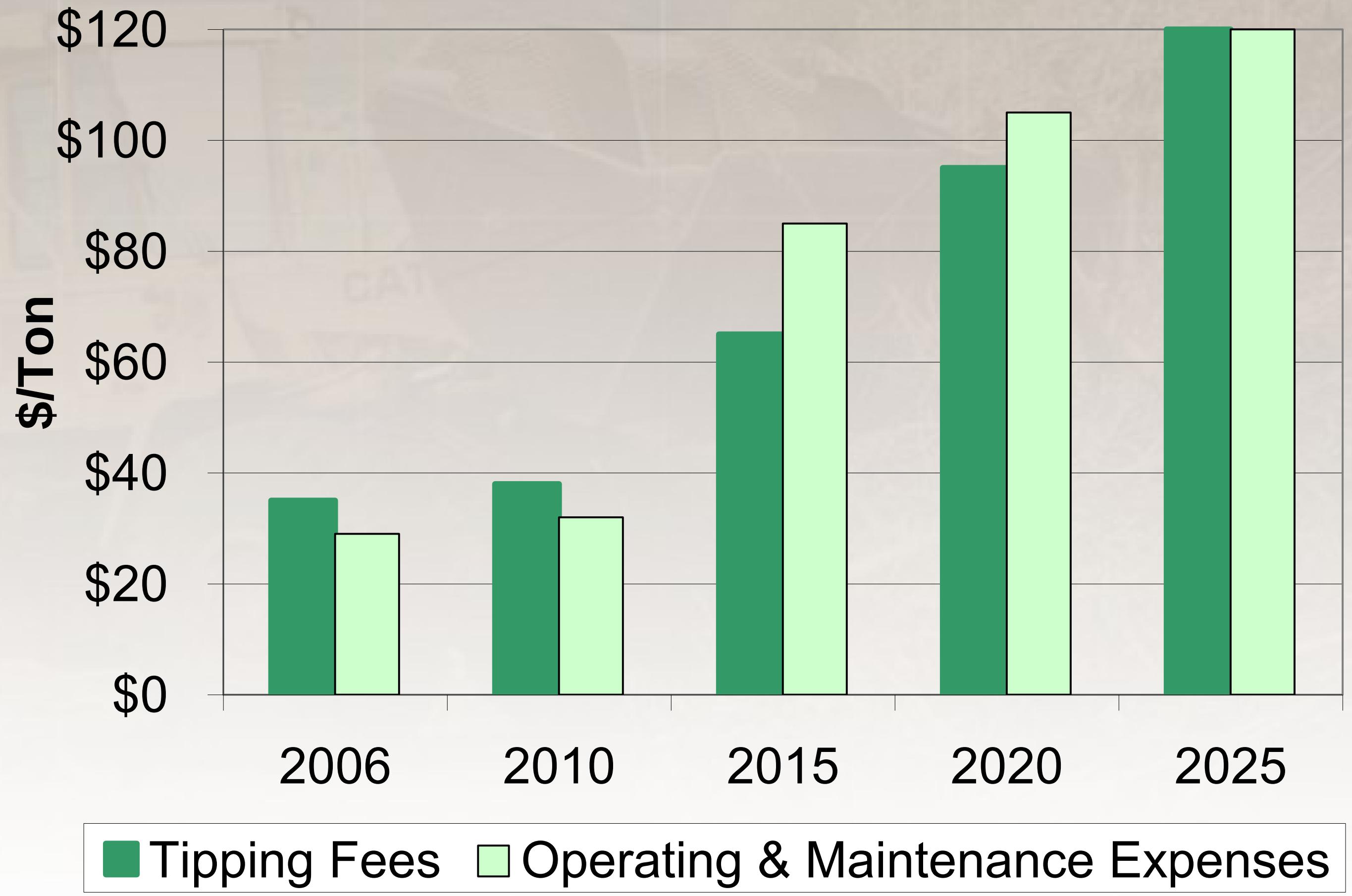
Year	Windrow	Aerated Static Pile
2006	100%	0%
2010	100%	0%
2015	75%	25%
2020	50%	50%
2025	50%	50%

Anaerobic Digestion

Year	Wastewater Treatment Plant Expansion	Stand Alone
2006	100%	0%
2010	100%	0%
2015	75%	25%
2020	50%	50%
2025	50%	50%

Key Assumptions – Future Operation Changes

- Mesquite Regional Landfill



Total Waste System Net Costs – Annual Capital Costs

- Used estimates of annual capital expenditures provided for the options.
- Used reported or estimated debt service or depreciation as a surrogate for annual capital costs.
- Unit capital costs were compared to the project team's experience on similar projects and vendor estimates to gauge the degree of reasonableness of the unit capital costs.
- Cost projections based on general inflation.
- Changes in technology or operations are reflected in projected capital costs if data was available.
- Regional differences were reflected using the California Wage Price Index if data was not available.

Total Waste System Net Costs – Additional Facility Costs

- Existing capacity information was not available.
- Assumes existing capacity through 2010 with new facilities needed starting in 2015.
- Assumes no WTE facilities until 2020 assuming a longer lead time for siting and permitting in the SBA and SCV regions.
- No new landfills assumed except for the Mesquite landfill.
- Assumed average future facility sizes and capital cost projections based on data collected and project team experience.
- Includes cost for land estimated at 5% of capital costs.

Key Assumptions – Additional Facility Costs

Facilities	Tons Per Year
Landfill	n/a
Anaerobic Digestion	25,000
Biomass-to-Energy	100,000
Chipping/Grinding	60,000
Composting	100,000
Recycling	114,000
Waste-to-Energy	620,000

Anaerobic Digestion Net Costs

- 18 data points primarily from CA-based studies.
- Assumed WWTP operations for early years; stand alone AD operations for later years.
- Revenues included tip fees, sale of compost, recyclable materials sales, carbon credits and energy sales.
- Operating costs included labor and maintenance costs.
- Capital costs based on stand-alone AD facilities for new facilities.
- Average new facility size estimated at 25,000 tons per year.

Biomass-to-Energy Net Costs

- Based on 1 data point and R.W. Beck BTE experience .
- Data received was relatively high quality, CA-based, comprehensive and reflective of standard BTE facilities in CA.
- Revenues included sale of energy and carbon credits.
- Operating costs included labor and maintenance.
- Annual capital costs estimated based on annual replacements.
- Average new facility size estimated at 100,000 tons per year.

Composting Net Costs

- **Costs were developed for windrow and ASP technologies.**
- **8 surveys completed for windrow technologies.**
- **ASP costs estimates were developed based on discussions with industry representatives.**

- **Revenues included tip fees, cogeneration fuel sales, sale of finished compost, carbon credits.**
- **Operating costs included labor and maintenance.**
- **Average new facility size estimated at 100,000 tons per year.**

Chipping/Grinding Net Costs

- Chipping/grinding costs estimates were developed based on discussions with industry representatives.
- Revenues included tip fee revenues and cogeneration fuel sales.
- Operating costs included labor and maintenance.
- Average new facility size estimated at 60,000 tons/year.

MRF, C&D and Self Haul/Baling Net Costs

- 14 surveys received mainly from large, automated MRFs.
- 2007-2008 Materials Recycling and Processing in the United States, Governmental Advisory Associates used as a resource.
- Average new facility size: 114,000 tons/year
- Density factors applied to determine C&D and self haul/baling revenues and costs.
- Revenues included tip fee revenues, material sales.
- Operating costs included labor and maintenance.

Waste-to-Energy Net Costs

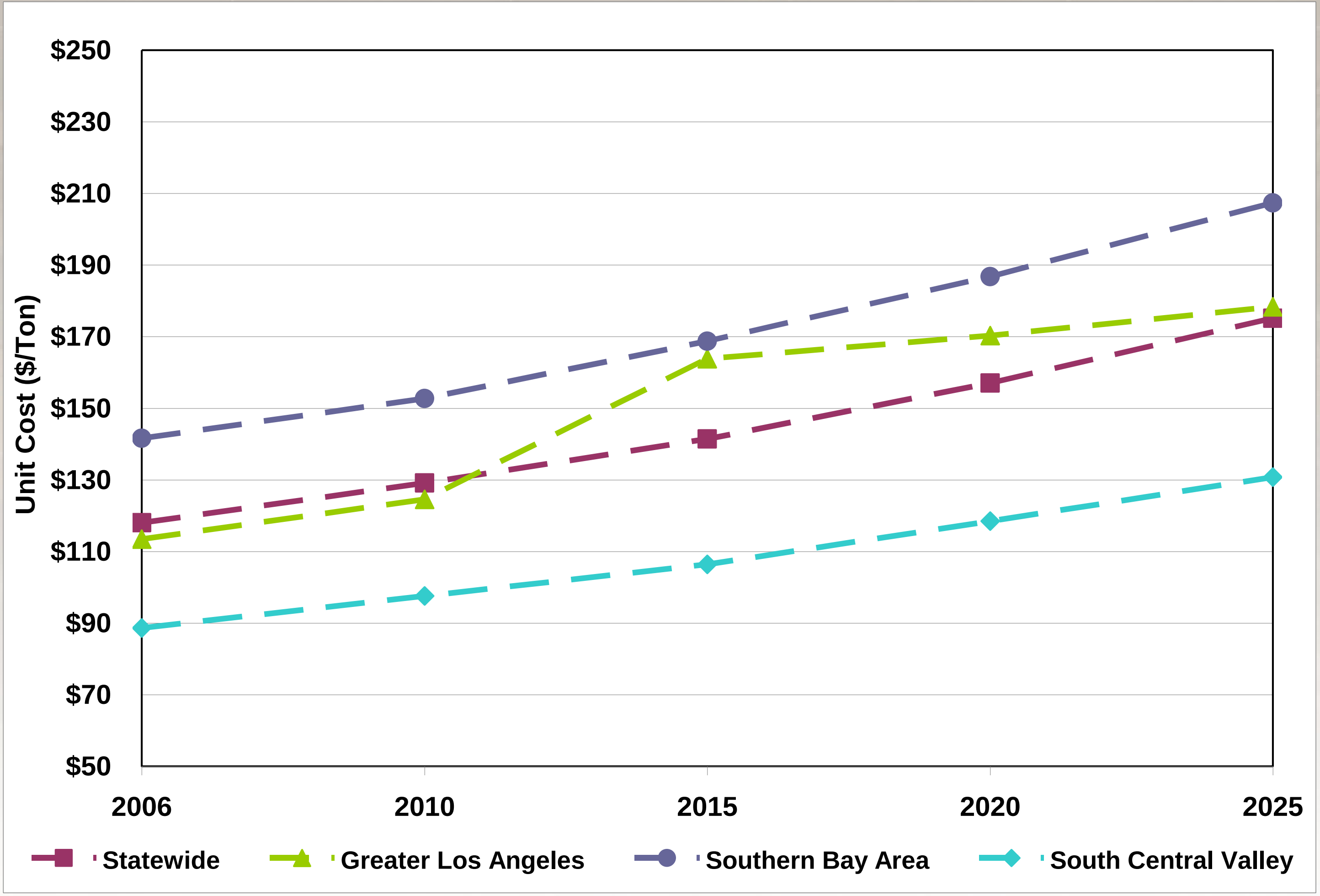
- Obtained partial data from public sources for 3 CA-based WTE facilities.
- Used R.W. Beck experience to develop data as necessary.
- Revenues included tip fees and sale of electricity.

- Operating costs included labor and maintenance.
- Average new facility size estimated at 620,000 tons per year.

5 Scenario Analyses

- Baseline Landfill
- Minimum Cost
- Minimum GHG
- Minimum Energy
- Minimum Cost Meeting GHG Targets

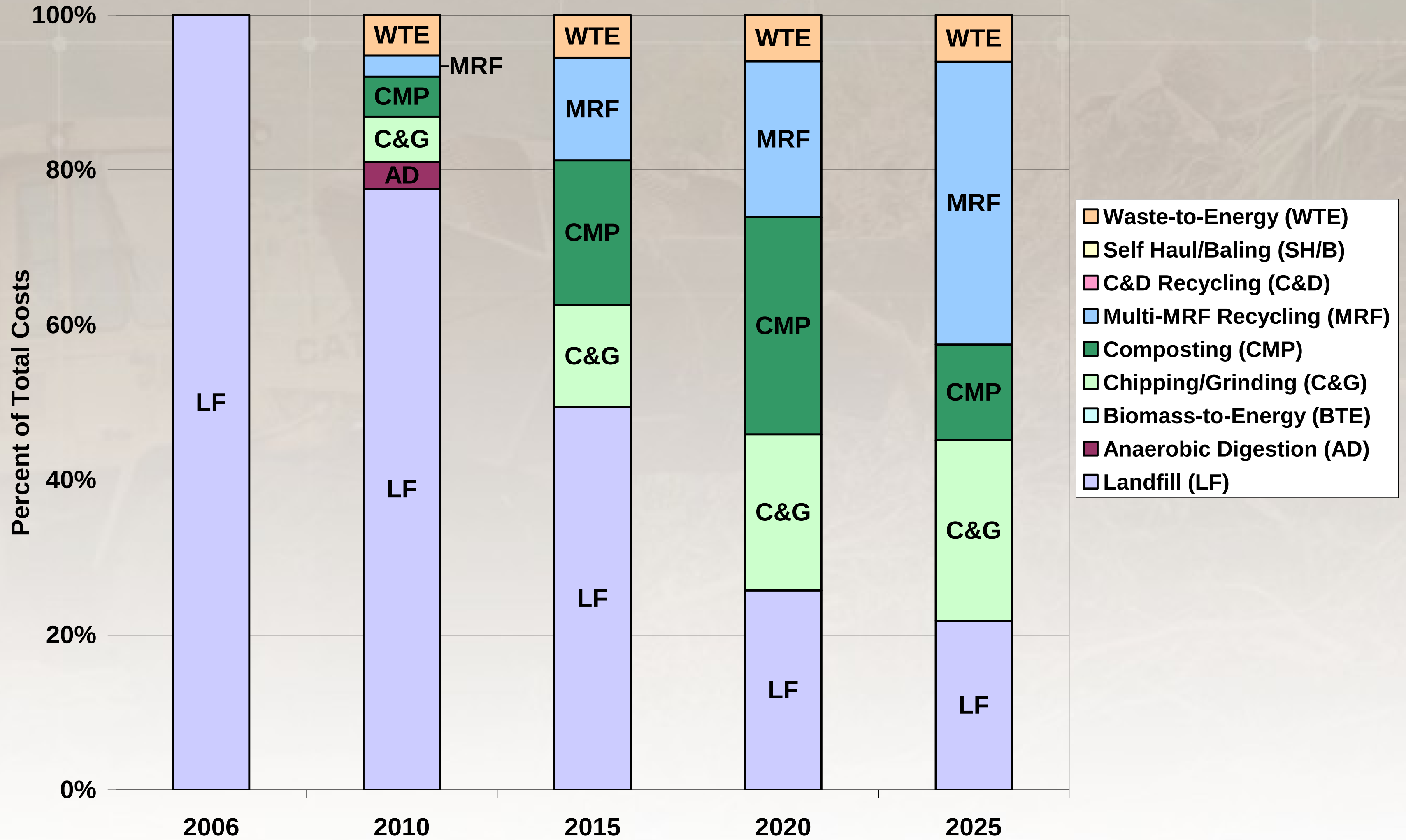
Scenario Analyses Results – Landfill Baseline Scenario($/ton)



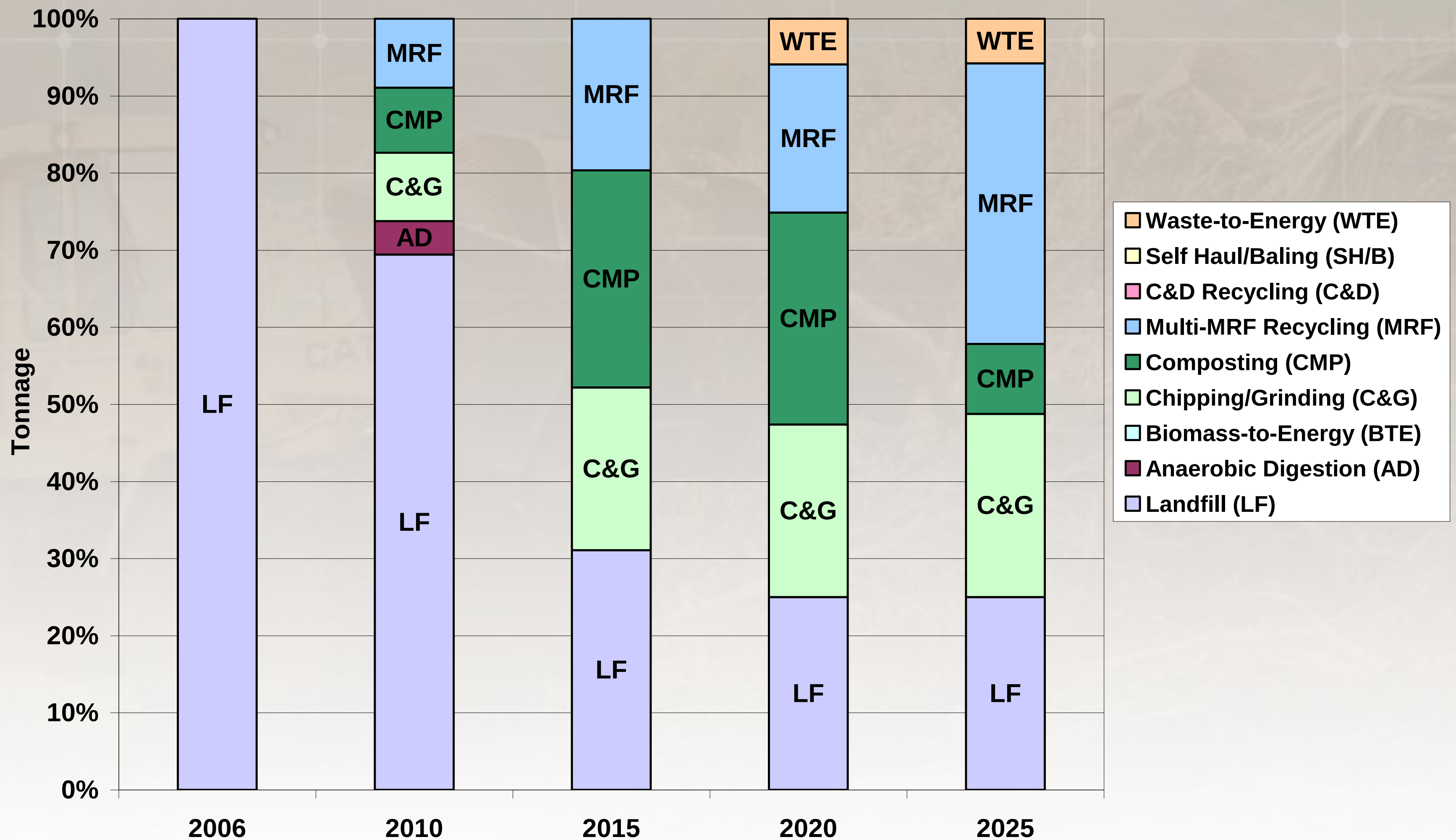
Sample Minimum Cost Calculation

Line		Chipping/Grinding - Statewide				
		Total Life Cycle Costs by Material Type and Process ($000)				
		2006	2010	2015	2020	2025
1	C&D - Lumber					
2	Total C&D - Lumber Tonnage	n/a	4,443,543	4,833,550	5,654,787	5,613,564
3	Tonnage Landfilled	n/a	3,554,834	2,658,452	1,696,436	1,403,391
4	Percent of Waste Material Tonnage	n/a	80.0%	55.0%	30.0%	25.0%
5	Tonnage for Each Waste Management Option	n/a	888,709	2,175,097	3,958,351	4,210,173
7	Percent of Total Waste Material Tonnage	n/a	20.0%	45.0%	70.0%	75.0%
8						
9	Collection Costs					
10	Residential Unit Cost ($/Ton)	n/a	$165	$186	$209	$235
11	Residential (Percent of Tonnage)	n/a	40%	40%	40%	40%
12	Residential Collection Costs ($000)	n/a	$58,620	$161,570	$331,080	$396,430
13	Commercial Unit Cost ($/Ton)	n/a	$132	$149	$167	$188
14	Commercial (Percent of Tonnage)	n/a	60%	60%	60%	60%
15	Commercial Collection Costs ($000)	n/a	$70,330	$193,930	$397,340	$475,670
16	Net Processing Income (Cost)					
17	Unit Net Processing Income/(Cost) ($/Ton)	n/a	$7	$8	$9	$10
18	Total Net Processing Income/(Cost)	n/a	$6,220	$17,400	$35,630	$42,100
19	Additional Facilities					
20	Average Facility Size (Tons)	n/a	n/a	60,000	60,000	60,000
21	Estimated Additional Facilities	n/a	n/a	36.3	29.7	4.2
22	Unit Additional Facilities Cost ($/Ton)	n/a	n/a	$21	$24	$27
23	Total Incremental Facility Costs ($000)	n/a	n/a	$45,680	$42,800	$6,800
24	Annual Capital Financing					
25	2006	n/a	n/a	n/a	n/a	n/a
26	2010	n/a	n/a	n/a	n/a	n/a
27	2015	n/a	n/a	$3,670	$3,670	$3,670
28	2020	n/a	n/a	n/a	3,430	3,430
29	2025	n/a	n/a	n/a	n/a	550
30	Total ($000)	n/a	n/a	$3,670	$7,100	$7,650
31	Transportation Costs					
32	Domestic Markets					
33	Truck Unit Cost ($/Mile)	n/a	$1.90	$2.20	$2.40	$2.70
34	One Way Distance (miles)	n/a	10	10	10	10
35	Product as a Percent of Total Material Waste	n/a	99%	99%	99%	99%
36	Tons of Product	n/a	879,821	2,153,346	3,918,768	4,168,072
37	Total Product Transportation Costs	n/a	$670	$1,890	$3,760	$4,500
39	Residuals					
40	Truck Unit Cost ($/Mile)	n/a	$1.90	$2.20	$2.40	$2.70
41	One Way Distance (miles)	n/a	15	15	15	15
42	Residual as a Percent of Total Material Waste	n/a	1%	1%	1%	1%
43	Tons of Residuals	n/a	8,887	21,751	39,584	42,102
44	Total Residual Transportation Costs ($000)	n/a	$10	$30	$60	$70
45	Total Costs ($000)	n/a	$123,410	$343,690	$703,710	$842,220
46	Total Costs ($/Ton)	n/a	$139	$158	$178	$200
47	Minimum Cost Ranking	n/a	1	1	1	1

Scenario Analyses Results – Minimum Cost Scenario - State Options



Scenario Analyses Results – Minimum Cost Scenario – SBA Options



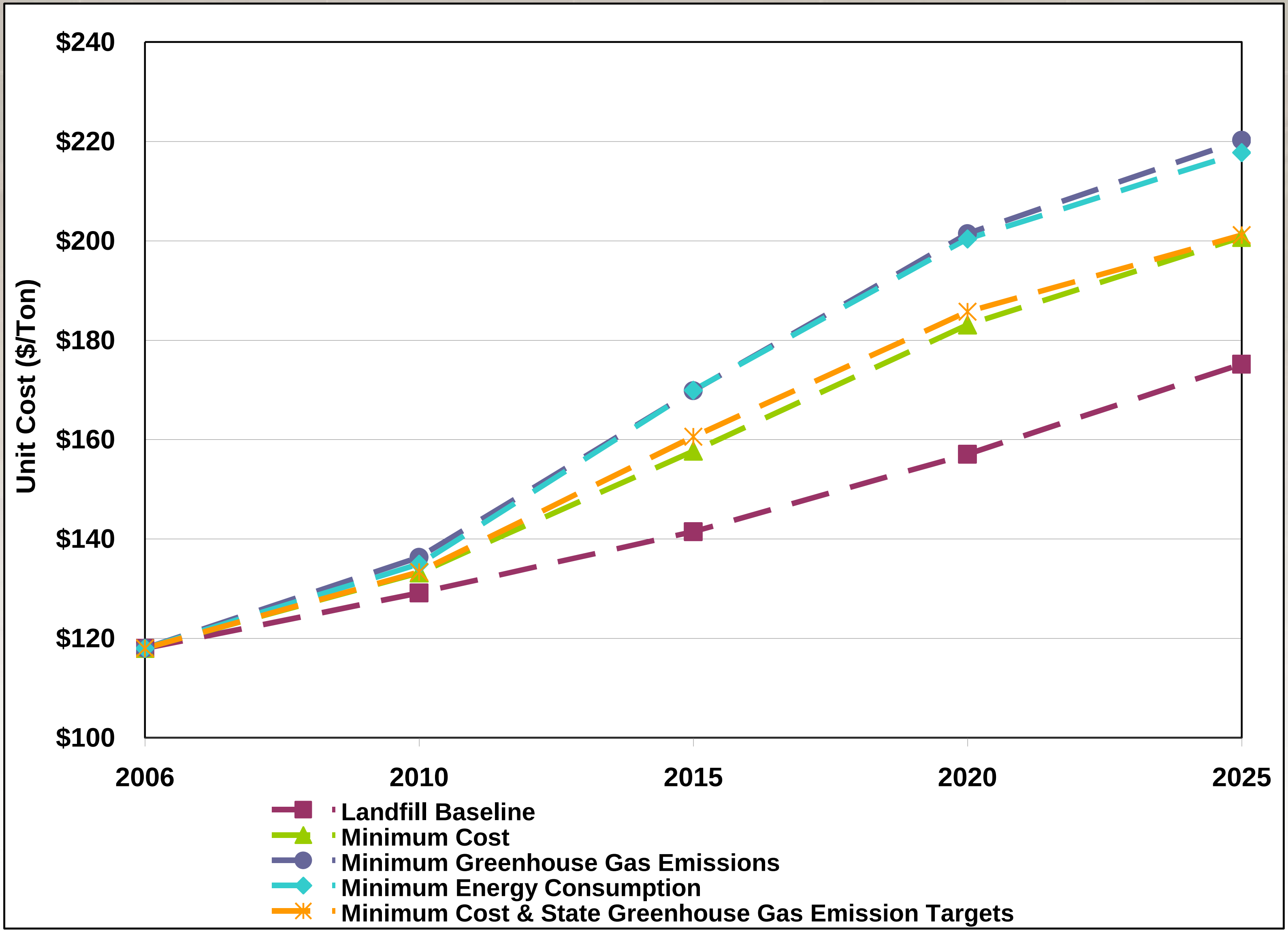
Scenario Analyses Results – Minimum Cost Scenario Add'l Facilities

Year	Landfill	Anaerobic Digestion	Biomass-to-Energy	Chipping/ Grinding	Compost	Multi-MRF Recycling	C&D Recycling	Self Haul/ Baling	Waste-to-Energy	Total
2015	n/a	0.0	0.0	99.9	80.7	38.8	0.0	0.0	3.2	222.5
2020	n/a	0.0	0.0	85.1	66.2	35.2	0.0	0.0	2.0	188.4
2025	n/a	0.0	0.0	26.5	3.8	9.8	0.0	0.0	0.3	40.4
Total (2015-2025)	n/a	0.0	0.0	211.4	150.7	83.7	0.0	0.0	5.5	451.4

Scenario Analyses Results – Additional Facilities

	Landfill	Anaerobic Digestion	Biomass-to-Energy	Chipping / Grinding	Composting	Multi MRF Recycling	C&D Recycling	Self Haul/ Baling	Waste-to-Energy	Total
Landfill Baseline	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Minimum Cost	n/a	0.0	0.0	211.4	150.7	83.7	0.0	0.0	5.5	451.4
Minimum Greenhouse Gas Emissions	n/a	73.9	0.0	0.0	0.0	46.9	36.9	80.8	32.4	270.9
Minimum Energy Consumption	n/a	0.0	0.0	0.0	0.0	19.1	0.0	30.8	56.5	106.4
Minimum Cost & State Greenhouse Gas Emission Targets	n/a	0.0	0.0	211.4	64.1	163.8	0.0	0.0	5.5	444.9

Scenario Analyses Results – Comparison Results ($/ton)



Scenario Analyses Results – Minimum Cost Scenario ($/MTCO2E)

Line	Change from Baseline	2006	2010	2015	2020	2025
1	Total Costs ($000)	n/a	n/a	n/a	$1,393,250	$1,387,390
2	$MTCO2_e$ Savings	n/a	1,570,236	2,491,321	(1,292,457)	(19,129,119)
3	$/MTCO2_e$	n/a	n/a	n/a	$1,078	$73

- Change in 2020-2025 reflects shift from composting to MRFs as revenues from MRFs are high enough by 2025 to offset high transport costs relative to composting.

Scenario Analyses Results – Minimum Cost & GHG Targets Scenario ($/MTCO2E)

Line	Change from Baseline					
		2006	2010	2015	2020	2025
1	Total Costs	n/a	n/a	$870,380	$1,535,500	$1,411,310
2	$MTCO2_e$	n/a	802,948	(7,157,283)	(18,848,053)	(19,129,119)
3	$\$/MTCO2_e$	n/a	n/a	$122	$81	$74

- Change in 2015-2020 reflects shift from composting to MRFs in order to meet GHG targets.

Scenario Analyses Results Minimum GHG ($/MTCO2E)

Line	Change from Baseline					
		2006	2010	2015	2020	2025
1	Total Costs	n/a	$295,670	$1,289,880	$2,375,640	$2,446,210
2	$MTCO2_e$	n/a	(6,932,802)	(16,735,113)	(30,279,333)	(31,646,331)
3	$\$/MTCO2_e$	n/a	$43	$77	$78	$77

- This scenario yields the lowest $/MTCO2e since the goal is max GHG reduction.

Scenario Analyses Results – Minimum Energy Scenario ($/MTCO2E)

Line	Change from Baseline					
		2006	2010	2015	2020	2025
1	Total Costs	n/a	$239,530	$1,295,420	$2,317,750	$2,313,140
2	$MTCO2_e$	n/a	(1,058,483)	(2,370,162)	(4,143,935)	(3,878,962)
3	$/MTCO2_e$	n/a	$226	$547	$559	$596

- This scenario yields the highest $/MTCO2e due to lower emission reductions relative to the other scenarios.

IMPLAN Results

- Direct Impacts
  - Largest value of production – Landfills
  - Smallest value of production – WTE
- Total Multiplier
  - Range on a statewide basis was 1.73-5.62
  - Lowest was chipping/grinding
  - Highest was WTE
- Results should be viewed as one indicator of economic feasibility.
- Difficult to project out longer than 5-6 years past the data reported due to changes in technology and consumer behaviors.

Next Steps

- Compile and prioritize stakeholder comments (August)
- Finalize report (September-October)

Questions and Answers